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A REVIEW OF OIL POLLUTING INCIDENTS IN AND AROUND NEW ENGLAND

by

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ABSTRACT

The following report offers a comprehensive review of oil pollution incidents in and around New England waters. The first section of the report presents an analysis of all oil discharge data maintained by the U.S. Coast Guard for years 1973 through 1975. The data are analyzed categorically to reveal where most spills occur in New England waters, where the greatest quantities are spilled, what types of oil are most frequently spilled, what types are spilled in the greatest quantities (in gallons), what the most significant sources and causes of spills are, and within which size range (in gallons) most spills occur. The second section offers synopses of the more publicly recognized spills which have occurred within the last twenty-five years. The management of oil discharges and areas in which additional research is required are discussed in a concluding section.

Work for this report was completed as of February 14, 1977.

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INTRODUCTION

The reality of oil exploration off the New England coastline has alarmed many, including the citizen, scientist, and decision maker. All are concerned with a basic question. Are New England's aquatic resources threatened in view of potential offshore petroleum development and the possibility of a consequent increase in oil polluting events in and around New England waters?

Further research to elucidate ecological and socioeconomic effects is one necessary approach to answering such a question. However, there is also much to be learned from an existing yet incompletely synthesized data base. An analysis of existing data relating to the nature and impact of oil pollution events can be useful both in terms of bettering our understanding of the environmental consequences of oil contamination and providing a basis of comparison with future spill data. Accordingly, the following report has been completed in response to an in-house request from the Narragansett Environmental Research Laboratory of the Environmental Protection Agency to review the nature and environmental impact of previous oil discharges within New England[1] waters.

The first section of the review summarizes the number and volume of all oil discharges recently reported to the U.S. Coast Guard.[2] Such data are presented categorically to reveal where most spills occur, where the greatest quantities are spilled, what type of oil is most frequently spilled (by number), what type is spilled in the greatest quantity (in gallons), what the most significant sources and causes of spills are, and within which size range (in gallons) most spills occur. The second section offers synopses of the more publicly recognized spills, most of which have been evaluated through follow-up ecological investigations and are documented in the literature. The management of oil discharges and areas in which additional research is required are discussed in a concluding section.

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[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, and Connecticut.

[2] Information received through the courtesy of the U.S. Coast Guard, Marine Environmental Protection Division, Coast Guard Headquarters, Washington, D.C.

Previous reviewers (Hyland and Schneider, 1976; National Academy of Sciences, 1975; Boesch, et al., 1974; Nelson-Smith, 1973; Moore, et al., 1973) have described oil spills and their environmental effects, but on a more or less national or global scale. Until now, a review f oil spill information specific for New England waters has not existed. The information has remained in back newspaper files or in the Coast Guard's computerized Pollution Incident Reporting System, or is dispersed throughout the literature as individual, nonintegrated reports. It is anticipated then that the following review will be extremely useful in making this information available within a single, coherent source.

COAST GUARD REPORTED SPILLS

The U.S. Coast Guard, U.S. Geological Survey, and the Environmental Protection Agency now share an array of oil spill control, prevention, and enforcement responsibilities. Many of these responsibilities, as exercised today, were authorized under the Water Quality Improvement Act (WQIA) of 1970, an amendment to the original Federal Water Pollution Control Act (FWPCA) of 1948. One authorization under the act designated the Coast Guard as the official federal agency responsible for receiving notification of discharges of oil in harmful quantities from vessels or facilities into U.S. waters.

To facilitate the successful fulfillment of this responsibility (as well as others), the Coast Guard established in 1971 the Marine Environmental Protection Program (MEP). One immediate goal of MEP was to create an effective system for retrieving information concerning discharges of oil and other hazardous materials. Accordingly, MEP developed in December of 1971 the Pollution Incident Reporting System (PIRS). This is a computerized system capable of storing categorized data relating to oil discharges (Leotta and Wallace, 1975).

Through the use of the PIRS, and commencing with 1973, oil discharge information for New England waters was retrieved and is made available herein to the reader (Tables 1-6, and preceding Caveat). The data (number and quantity in gallons) are presented for each of the following categories: size of spill (in gallons) versus location, type spilled, source, and cause. Coding information for each category appears in the Coast Guard's coding manual (USCG, 1976). It must be pointed out that prior to 1973, oil discharge data are not complete as a result of either the incomplete development of the PIRS, or as a result of fewer people being aware of the legal requirements to report discharges to the Coast Guard (U.S. Coast Guard, 1973). 1976 data are still being received.

Table 1 reveals that a total of 1,524 oil spills, amounting to over 1,022,102 gallons, were reported between 1973 and 1975. These values represent only 4.7% of the total number of oil spills occurring in all U.S. waters, and 2.2% of the total volume spilled. In contrast to the Gulf region which is the site of extensive oil production and refining and which received approximately 33% of the nation's total number of spills (USCG, 1973-1975), the New England region currently experiences

no oil production and has just one operating refinery (in East Providence, Rhode Island) whose crude capacity is only 0.05% of the nation's total (Petroleum Publishing Co., 1976).

Table 1 also reveals that a slight decrease in oil spillage has occurred between 1973 and 1975, since 560 spills (amounting to over 490,862 gallons) were reported for 1973, while 497 spills (amounting to over 248,451 gallons) were reported for 1974, and 467 spills (amounting to over 282,789 gallons) were reported for 1975. It is impossible to determine at this time whether such a trend extended throughout 1976 (i.e., in terms of number of spills), since PIRS data for that year are not yet available. However, the volume of oil released as a result of one incident alone during 1976 exceeded seven times the combined volume spilled from all sources during the previous three years. The incident in mention was the grounding and sinking of the Liberian tanker Argo Merchant on December 15, 1976, which led to the release of approximately 7.6 million gallons of No. 6 industrial fuel oil into offshore waters 27 miles southeast of Nantucket Island. Thus, at least in terms of volume of oil spilled, during 1976 New England experienced a dramatic increase over previous years.

Table 2 reveals that of the total 1,524 spills reported between 1973 and 1975, over 50% were extremely small, i.e., under 50 gallons (approximately one barrel). In contrast, the 15 spills amounting to over 10,000 gallons each (representing together less than 1% of total number spilled) accounted for 72% of the total volume spilled. Table 2 also reveals that a large number of the reported spills were of unknown volume. Therefore, it must be noted that the figures reported in the preceding paragraphs, representing the total volume of oil spilled, are somewhat conservative.

Table 3 reveals that between 1973 and 1975 the greatest number of spills in New England (76.5%), as well as the greatest volume spilled (75.5%), occurred in coastal waters. This is of concern to many, since coastal areas are extremely rich in living resources. Coastal waters refer herein to bays, estuaries, sounds, harbors, ports, channels, beaches, and certain river areas, all occurring between the boundaries set by the US CG and EPA for inland waters (upstream of coastal waters) and the contiguous zone (3 to 12 miles seaward). Open coastal waters out to the contiguous zone are represented as a separate category. High seas refer to waters further than 12 miles from shore.

Table 4 reveals that light oils (representing 44.5% of the total number spilled) were the most frequently spilled in New England waters. Light oils include light crude and light diesel oils, gasoline, and the distillate fuel oils (jet fuels, including JP-1 through JP-5; Kerosene; and numbers 1 through 3

heating oils). Light oils were also spilled in notable quantities (40.0% of total volume); however, heavy oils contributed to over 57% of the total quantity spilled. Heavy oils include heavy crude and diesel oils, residual fuel oils (numbers 4 through 6), and other residuals (creosote, asphalt, and coal tar). Waste oil refers to substances such as used crankcase oil. "Other oils" include substances such as lube oil, liquefied petroleum gas, hydraulic fluid, lacquer-based paint, paraffin wax, grease, mixtures of two or more petroleum products, oil-based pesticides, and unidentified light and heavy oils.

Tables 5 and 6 summarize the sources and causes of oil spills in New England between 1973 and 1975. The source of most spills could not be identified (unknown sources accounted for 34.6% of the total number of spills); however, of those which could be determined, most involved either a vessel (tanker, barge, dry cargoship, tugboat, federal vessel, fishing vessel, passenger vessel, recreational vessel) or a non-transportation related facility (including tank farms, industrial plants, power plants, pipelines within non-transportation related facilities, and processing facilities). Together, all vessels contributed to nearly 38% of the total number of spills, while non-transportation related facilities contributed to over 16%. The largest quantities spilled were attributed to the same sources.

The cause of most spills also could not be identified, as unknown causes contributed to approximately 40% of the total number of spills. The most significant known causes, however, included personnel and equipment failures, which contributed to 20.0% and 18.6% respectively. Personnel failures include inadequate soundings, errors leading to tank overflows, and the improper handling and operation of equipment during cargo transfers. Equipment failures include leaks or ruptures in pipelines, hoses, manifolds, and loading arms, and general operational failures in pumps, flanges, gaskets, and valves. The greatest volume of oil spilled (27.5% of total) also resulted from personnel failure. In addition, unknown causes contributed to 22.3% of the total volume spilled, while casualties contributed to 20.0%. Casualties refer to collisions, groundings, fires, explosions, capsizing or overturning, sinking, etc.

SINGLE MAJOR SPILLS

In the following section are described several of the larger, and with a few exceptions, more thoroughly investigated spills which have occurred in New England waters. Included for each spill is a general history of the event, along with a summary of the ecological and/or socioeconomic impact, if available. Accordingly, the following are documented: Muscongus Bay, Maine spill, November 25, 1963; Searsport, Maine spill, March-June, 1971; Casco Bay, Maine spill, July 22, 1972; Great Bay, New Hampshire spill, May 11, 1969; West Falmouth, Massachusetts spill, September 16, 1969; New Haven (Long Island Sound), Connecticut spill, January 23, 1971; Niantic Bay (Long Island Sound), Connecticut spill, March 21, 1972; and several major uninvestigated spills which occurred in the Narragansett Bay, Rhode Island, during the last 25 years.

MUSCONGUS BAY, MAINE OIL SPILL

On November 25, 1963, the Liberian tanker, Northern Gulf, ran aground on West Cod Ledge, Casco Bay, Maine, and spilled approximately 5,000 metric tons (approximately 1,540,000 gallons, based on a density of 0.86 for API reference crude oil) of crude oil. As a result of weather conditions, much of the oil was carried northeastward and accumulated in the Friendship-Bristol-Bremen area of Muscongus Bay. Damages as a result of the spill included immediate and continuous kill of soft-shell clams (Mya arenaria), and contamination of lobsters held in tidal storage impoundments. Damages to the clam and lobster fisheries were dramatic, amounting to the loss of 60 to 209 and 15.2 metric tons, respectively. Chemical analyses of sediments revealed persistence of weathered fractions of the crude oil at concentrations greater than 4,000 ppm, even 11 years after the original event.

The above information was reported by Mayo, et al. (1974) and Dow (1975). Effects on other organisms or communities of organisms, or pollution of subtidal areas, were not investigated.

SEARSPORT, MAINE OIL SPILL

Between March 16 and June 30, 1971, a minimum or 14 metric tons (approximately 4,300 gallons, based on a density of 0.86 for API reference No. 2 fuel oil) of No. 2 fuel oil mixed with JP-5 jet fuel spilled from the U.S. Air Force storage facility on

Long Cove, Searsport, Maine. Although at first the Coast Guard estimated that possibly no more than a barrel and a half entered the water, much of Long Cove and adjacent portions of Sears Island slowly became contaminated as a result of the spill. Follow-up ecological, chemical and histopathological investigations of the affected areas were conducted by a team of scientists from the Maine Department of Marine Resources, Bowdoin College, and the Environmental Protection Agency (Dow, et al., 1975). Acute toxicity of the spilled oil resulted in immediate and continuous mortality of soft-shell clams (Mya arenaria). Dow reported that of the estimated total of 50 million market-size clams occupying Long Cove and western Sears Island before the spill, 13% were killed by March 30, 1971; 25% by July 31, 1971; 55% by August, 1972; and 86% by August, 1974. The histopathological studies conducted by Barry and Yevich (in Dow, et al., 1975) revealed a high incidence of cancerous gonadal tumours in clams contaminated by the oil. Examination of some of the clams revealed that the tumour cells had invaded the entire bodies. The area of highest oil concentration (150 ppm in sediments) was correlated with the highest percentage of tumours found in the clams (10% of sample).

Only effects on clams were investigated.

CASCO BAY, MAINE OIL SPILL

On July 22, 1972, the Norwegian tanker, Tamano, ran aground in Hussey Sound, an entrance channel into Casco Bay, Maine, and spilled approximately 100,000 gallons of No. 6 fuel oil. It was estimated that approximately 30,000 gallons escaped cleanup attempts and contaminated 70% of the bay's shorelines, particularly the islands in the immediate vicinity. These facts together with the ecological effects were reported by The Research Corporation of New England under contract with the Environmental Protection Agency (TRC, 1975), and were further documented by Eidam, et al. (1975). Additional studies were performed by Gilfillan and Hanson (1974).

Intertidal mud flats were the most seriously affected areas. Here, oil accumulated in sediments as well as in the tissues of the abundant, soft-shell clam (Mya arenaria). Here, also, population densities and diversity within the bottom invertebrate community were lowered, and losses of polychaetes and bivalves were particularly notable. In one case, there was almost a complete loss of organisms, although gradual recovery was observed thereafter. Rocky intertidal areas were also affected, but to a lesser degree. Within these latter areas, large amounts of seaweed, barnacles, and amphipods were killed; and periwinkles were observed upside down in tidal pools. Chemical analyses revealed the incorporation of oil into the tissues of surviving rocky intertidal species. Subtidal bottom areas were apparently affected the least, since species diversity and population

densities were not severely altered. Chemical evaluation of these areas, however, revealed the ability of oil to pollute deeper, previously uncontaminated areas, and the gradual contamination of lobsters (Homarus americanus). Observations of several of the rookeries within the bay confirmed the death of waterfowl as a result of the spill.

A later phase of the study conducted one year after the spill revealed some signs of recovery. For example, in the intertidal areas, where seaweed was previously killed off, new fronds were beginning to appear; and population densities and species diversity within the bottom invertebrate communities were increasing. On the other hand, rocky areas still heavily oiled were void of animals such as barnacles. Furthermore, there was no evidence of resettlement of previously oiled, intertidal mud flats by newly arriving populations of shellfish.

The effectiveness of various cleanup procedures were also discussed in the reports.

In addition, the TRC report (1975) documented several other uninvestigated spills (that were reported to the Natural Resources Council of Maine) occurring along Maine's coastline. They were as follows:

1. August 9, 1969. Approximately 2,100 to 8,400 gallons of No. 6 fuel oil spilled from a tanker in Portland Harbor, and accumulated to some extent along the shore of Little Diamond Island, Casco Bay.

2. December 1, 1953. Approximately 3,000 to 4,000 gallons of gasoline spilled from a tanker which ran aground between Orr's and Bailey Island, Casco Bay.

3. April 24, 1964. Minimum of 4,200 gallons of "oil" spilled from a ship at Birch Point, Wiscasset.

4. October, 1953. "Oil" spilled from a boat at Castine, Penobscot Bay, and polluted nearby clam flats. An estimated 3,690 bushels of clams were lost as a result.

GREAT BAY, NEW HAMPSHIRE SPILL

On May 11, 1969, a vessel collided with the Kittery bridge in the Piscataqua River, Great Bay, New Hampshire, and spilled approximately 200,000 gallons of fuel oil. Oil accumulated in intertidal areas on the north shore of Little Bay, and in Fox Point Cove. This information together with a description of the ecological impact one month after the spill was documented by Croker (1969).

Most of the ecological damage occurred at the high tide marks on beaches where oil washed ashore, and included the immediate death of Spartina marsh grass and several species of molluscs, crustaceans, and polychaetes. Amphipod crustaceans of the genera Gammarus and Marinogammarus were particularly vulnerable. In addition, local fishermen confirmed the tainting of striped bass (Roccus saxatilis).

Yet, disregarding the above effects, one month after the spill conditions appeared normal. There was evidence of fresh growth of marsh grass. Macroalgae at all locations appeared normal. Several invertebrate species (11), including even Gammarus, were observed in various stages of reproduction. Furthermore, there was no evidence of reduction in species diversity of bottom communities within the spill areas. Croker claimed that the species which suffered mortality were still sufficiently abundant to restore their numbers to "normal" pre-spill levels.

Long-term ecological effects or pollution of subtidal areas were not investigated.

WEST FALMOUTH, MASSACHUSETTS SPILL

On September 16, 1969, the barge, Florida, ran aground off Fassett's Point, West Falmouth, in Buzzards Bay, Massachusetts. The rupture in her hull allowed approximately 600 metric tons (650,000 to 700,000 liters = 172,600 to 184,800 gallons also documented) of No. 2 fuel oil to spill into West Falmouth Harbor and the adjacent waters of Wild Harbor and Silver Beach Harbor. Because of the nearness to the Woods Hole Oceanographic Institution and the Marine Biological Laboratory at Woods Hole, the immediate as well as long-term ecological damages from the spill were well studied (Hampson and Sanders, 1969; Blumer, 1970; Blumer, Souza, and Sass, 1970; Blumer, et al., 1970; Blumer, et al., 1971; Blumer and Sass, 1972a and b; Sanders, et al., 1972; Sanders, 1974; Grassle and Grassle, 1974; Michael, et al., 1975).

Massive kills of fish, crustaceans, molluscs, and polychaetes were reported immediately after the spill from intertidal to subtidal (3 meters) areas (Hampson and Sanders, 1969). Dead benthic invertebrates (crustaceans, snails, and clams) were also observed in bottom samples collected offshore in 7-10 meters of water. As a result of the massive mortalities of benthic organisms, numbers of species as well as individuals were lowered notably in impacted areas (Sanders, et al., 1972).

Chemical analyses of samples collected several months to two years after the spill revealed that the oil was persistent and that it had spread out across the bottom to even deeper areas that were previously uncontaminated. For example, the

concentration of oil in sediments increased over several months from 500 ppm to 12,000 ppm (dry weight) in a subtidal area in Silver Beach Harbor (Blumer and Sass, 1972b). However, two years after the spill the concentration of oil in the sediments at Silver Beach had gradually decreased to about 1,000 ppm. The concentration of oil in the sediments in the marshes of Wild Harbor River increased from about 500 ppm at first to 1,650 ppm several months later, and then decreased to about 250 ppm two years later.

There was also evidence of the oil retaining its toxicity throughout subsequent years. For example, ampeliscid crustaceans were particularly affected by the oil's long-term toxicity (Sanders, et al., 1972). Other long-term effects included the persistence of petroleum hydrocarbons in animal tissues (Blumer, et al., 1971; Blumer, Souza, Sass, 1970), and the invasion of oil-devastated areas by pollution-resistant species, such as the polychaete, Capitella capitata (Blumer, et al., 1971; Grassle and Grassle, 1974).

Michael's (1975) investigation, five years after the spill, revealed signs of recovery; however, weathered hydrocarbons still persisted, and numbers of benthic species were still significantly low at both offshore and marsh stations. Some stations were still characterized by the presence of opportunistic species.

In addition to the ecological damages, there was also considerable economic losses. For example, commercial shellfishing of oysters, soft-shell clams, quahaugs, and scallops was prohibited in the affected areas. The total cost, including loss of the fisheries, legal expenses, loss of oil sales, and cleanup expenses amounted to almost half a million dollars (Blumer, et al., 1971).

In summary, the investigators demonstrated that the spill was responsible for immediate mortality of a wide range of organisms from intertidal to offshore areas, chronic pollution, persistence of oil in sediments and organisms, spread of pollution with the moving sediments to previously uncontaminated areas, destruction of fishery resources, and additional monetary losses.

NEW HAVEN, LONG ISLAND SOUND SPILL

On January 23, 1971, the tanker, Gettysburg, ran aground near the entrance to New Haven Harbor, Long Island Sound, and spilled approximately 387,000 gallons of No. 2 fuel oil into the shipping channel. Prevailing winds drove the oil onto shores eastward of the harbor, as far as the Guilford area.

Chemical analyses of sediments and animals (oyster, Crassostrea virginica; and white slipper shell, Crepidula plana) collected up to three months after the spill revealed contamination by hydrocarbons typical of the type of oil spilled (Raytheon Co., 1971).

Long-term ecological effects or effects on entire communities were not investigated.

NIANTIC BAY, LONG ISLAND SOUND SPILL

On March 21, 1972, the tanker, F. L. Hayes, ran aground on Bartlett Reef in Long Island Sound, and spilled approximately 80,000 gallons of No. 2 fuel oil into surrounding waters of Niantic Bay. A study of the spill was conducted by Vast Inc., under contract to the Environmental Protection Agency (1973). Most of the short-term (three months after spill) ecological damages were observed in a subtidal area in the middle of the bay, and included the disappearance of normally occurring amphipods. Hermit crabs of the genus, Pagurus, were also sensitive to the oil and were found to concentrate it in their tissues. Unlike inshore stations, the mid-bay station was the only area where oil was found in sediments in significant quantities. Apparently, the weathering action of a storm which occurred during the time of the spill spared the bay from serious contamination.

Long-term ecological effects of the spill were not investigated.

NARRAGANSETT BAY, RHODE ISLAND OIL SPILLS

Although not thoroughly investigated, or documented in the literature, several oil spills of relatively major sizes have occurred in the Narragansett Bay, Rhode Island, over the past twenty-five years. Information describing such spills on a superficial level, however, has been made available to the author through local reports, records, and communications with state and federal personnel employed in the vicinity. An emphasis on the coverage of these spills does not necessarily imply that oil spills in the Narragansett Bay occur more frequently or are more voluminous than in other coastal New England ports. In fact, Portland, Boston, and New Haven each handle a great deal more petroleum and petroleum products than do all ports together in the Narragansett Bay (MIT, 1973). Instead, a fuller coverage of Narragansett Bay spills is a result of the author's direct access to detailed spill information for this area. Accordingly, oil spills in Narragansett Bay are included hereinbelow.

Fort Wetherill, Jamestown

Weathered oil may be observed to date in underlying sediments of the westernmost cove at Fort Wetherill, Jamestown, at the mouth of the Narragansett Bay. Although no formal proof exists, some believe that the most probable source of this oil was from a spill which occurred on September 6, 1960, when the tanker, Thirtle ran aground in the immediate vicinity and spilled approximately 420,000 gallons of No. 6 fuel oil. The spill itself was extensive, covering shores from the mouth of the bay southward to at least the Watch Hill area.

An earlier spill of No. 6 fuel oil was also noted in the same area back on August 7, 1953. The source or quantity spilled was not positively identified.

Spills Near North Tiverton, Mount Hope Bay

Farrington and Quinn (1973) received the following information from the Rhode Island Department of Health concerning spills in the North Tiverton area, in the upper part of Narragansett Bay: January 8, 1969, 155 metric tons (approximately 48,000 gallons, based on a density of 0.86 for API reference No. 2 fuel oil) of No. 2 fuel oil spilled; January 8 and March 4, 1970, 22 metric tons (approximately 5,800 gallons, based on a density of 1.0 for API reference No. 6 fuel oil) of No. 6 fuel oil spilled.

The North Tiverton area is the site of oil storage facilities and is subjected to discharges associated with tanker offloading activities.

Popasquash Point Spill

On April 9, 1973, the Liberian tanker Pennant ran aground on a boulder off Popasquash Point, in the upper part of Narragansett Bay, and spilled approximately 250,000 gallons of No. 6 fuel oil. Areas polluted ranged from Bristol Point at the mouth of Mount Hope Bay to Sabin Point on the Providence River. Clean-up of visible "clumps" of oil was effective, however concern over ecological damages from unrecovered fractions was expressed among scientists at the Environmental Protection Agency and the University of Rhode Island, Narragansett. Subsequent sampling for ongoing baseline studies in the area revealed some abnormalities, such as the presence of oil droplets in plankton tows, including small droplets adhered to the appendages of the copepod, Temora longicarnis (H. P. Jeffries, University of Rhode Island, personal communications).

Chronic Pollution in Narragansett Bay

Chronic oil pollution in Narragansett Bay has been recognized, particularly in the upper parts of the bay, around the

mouths of the Providence River and Mount Hope Bay. Chronic inputs are contributed as a result of ship traffic including pleasure craft, small spills associated with off-loading tankers at the oil storage points, and sewage treatment effluents (Farrington, 1971). Farrington and Quinn (1973a) estimated that the Field's Point and East Providence sewage treatment plants, both located along the Providence River, discharge from 130 to 655 metric tons/yr and 4.9 metric tons/yr of petroleum hydrocarbons, respectively. Assuming a density of 0.90 for the types of materials involved (from Farrington, 1971), then it can be estimated that between 39,700 and 194,000 gallons of oil per year enter the bay from these sources alone. Inputs from such sources are often unreported since the oil does not instantaneously contaminate the body of water by forming a noticeable sheen, but gradually accumulates on the bottom through time via oil-laden sediment or particulate matter. Concentrations of petroleum hydrocarbons in the sediments may range from 820-3,560 ppm (dry weight) in areas around sewage treatment outflows (Farrington and Quinn, 1973b).

DISCUSSION

Major spills and localized repeated discharges continue to contribute substantial quantities of petroleum hydrocarbons to New England waters. Levels harmful to marine organisms have been found in some areas, particularly coastal areas subjected to the larger vessel spills, to oily sewage and industrial treatment effluents, or to contamination resulting from activities near storage facilities. For example, oil has been observed in the sediments at levels as high as 12,000 ppm (dry weight) after the West Falmouth spill, and up to 3,560 ppm in areas including the upper part of Narragansett Bay, R.I., which are subjected to chronic oil stress. At an oil-in-sediment concentration of approximately 500 ppm, which was observed immediately after the West Falmouth spill, a wide range of organisms were killed.

The ecologically harmful effects from spilled oil most often result from either its chemical toxicity or from the effects of physical coating, entanglement, and smothering. Damages have included the endangering of seabird species, immediate and continuous mortality of fish and invertebrate species, sublethal behavioral changes of certain species, modification of intertidal to subtidal benthic communities, and contamination of commercially important species of fish and shellfish. The latter category has involved the tainting of meats, as well as the contamination of certain palatable species with compounds that are potentially carcinogenic to man. Incidence of cancer has been evidenced among clams sampled from oil spill sites. Aesthetic infringements have resulted from the oiling and tarring of beaches, as well as the loss of living resources.

Spillage of oil in New England waters creates a coastal management problem. These biologically productive coastal areas receive the greatest percentage of oil spilled, both by number and volume, and as revealed herein, often experience considerable losses of living resources as a result. Those charged with management responsibilities then should decide how to effectively reduce petroleum inputs, especially if nearshore petroleum-related activities should increase as a result of future oil development.

Van Cleave (1973) has estimated that spill cleanup operations are typically 20% efficient, and further reasons that the best solution to reducing inputs is the implementation of

effective spill prevention. Recent proposals and recommendations may provide useful guidelines for preventing discharges of oil into New England waters (as well as other bodies of water). For example, Van Cleave discusses how the Environmental Protection Agency has developed the Spill Prevention control and Countermeasure (SPCC) concept, which is a spill prevention program designed for non-transportation related facilities. The SPCC concept proposes stiffer penalties for violation of regulations, and encourages the development of effective contingency planning and response prior to the spillage. Van Cleave claims an 80% reduction in petroleum inputs from non-transportation related activities through implementation of the SPCC.

A more general approach to spill prevention was recommended by the National Academy of Sciences during a recent workshop on the fate and effects of petroleum in the marine environment (NAS, 1975). The recommendations called for improvements in the control of tanker and shipping operations, municipal and industrial wastewater treatment processes, and petroleum hydrocarbon emissions from automobiles and other internal combustion engines. The successful implementation of such recommendations should significantly reduce chronic inputs as well as inputs from larger, single spills.

The best available prevention technology will not eliminate all spills. So, the next best management tactic is the implementation of appropriate cleanup measures. The nature of the spill and the environmental conditions must be investigated first, however, to assure that the most effective and least harmful cleanup practice is employed. Various cleanup techniques and relevant training programs are reviewed in the proceedings of several recent symposia (API and FWPCA, 1969; API, 1970; API, EPA, USCG, 1973; NBS, 1974; API, EPA, USCG, 1975).

In addition, follow-up field investigations of the more major spills should be conducted to assess their fate and impact, while controlled laboratory and field studies should be performed to help elucidate such fate and effects and to aid in determining ultimately what levels of petroleum hydrocarbons are "safe" for aquatic organisms and/or man. When performing these investigations standardized biological and chemical techniques should be encouraged in order to develop a more reliable and accurate data base. Studies concerning the fate of spilled oil should be directed at defining the mechanisms which determine the "mass balance" of a particular oil spill. In other words, for a given spill with its unique conditions, how much of the oil evaporates into the atmosphere, how much accumulates at the air-water interface, how much dissolves or disperses into the water column, and how much accumulates in the sediment? As pointed out in the National Academy of Science

report (NAS, 1975), such an understanding would be invaluable in terms of defining which cleanup method should be employed, which ecological compartments would be most vulnerable for a particular spill, and which precautionary and/or corrective measures should be taken to minimize the ecological impact of the spill. Ecological studies should emphasize effects on entire communities, subtidal as well as intertidal; effects on significant and/or sensitive components thereof (e.g., community dominants; commercially or ecologically important species; or sensitive species such as the amphipod crustaceans revealed herein); assessment of long-term effects; and the identification of levels of oil in sediments, organisms, and the water column. In addition, baseline studies are extremely useful as yardsticks for monitoring ecological changes that may accompany offshore oil development or nearshore petroleum-related activities. The Bureau of Land Management (BLM) is now engaged in sponsoring baseline studies for those Outer Continental Shelf (OCS) areas (e.g., Georges Bank) that are under consideration for petroleum development.

So far, studies have revealed that oil-polluted areas within New England experience at least interim losses of living resources. However, as the National Academy of Sciences asked during their recent workshop (NAS, 1975), "At what level of petroleum hydrocarbon input . . . might we find irreversible damage occurring?" The final recommendation to coastal managers and other decision makers, then, is to provide incentives for research directed at answering this question of utmost concern.

ADDENDUM

The author has attempted to provide in this report a comprehensive review of oil pollution incidents in and around New England waters. However, even during the final editing of the manuscript, New England experienced a rash of publicly recognized incidents involving the discharge of oil, or vessels that carry oil. So, in an effort to generate a review that is as comprehensive as possible, the manuscript is hereinbelow supplemented with accounts of these rather recent incidents.

On November 10, 1976, approximately 1,500 gallons of No. 6 fuel oil spilled from a storage tank at Quonset Pt., Rhode Island, and leaked through a storm drain into the Narragansett Bay. Much of the oil was driven southeastward and contaminated approximately one mile of shoreline in the Sand Point area of Jamestown Island. One day later, approximately 1,300 gallons of No. 6 fuel oil leaked from a ruptured storage tank at the Ban Realty Company, Barrington, Rhode Island, and contaminated neighboring sections of a marsh in Allen's Cove. On December 15, the Liberian tanker, Argo Merchant, ran aground 27 miles southeast of Nantucket and discharged 7.6 million gallons of No. 6 fuel oil into prime fishing grounds. On December 22, approximately 2,500 gallons of No. 6 fuel oil leaked from a fractured underground pipeline at the Narragansett Electric Company, Providence, Rhode Island, and contaminated waters in the vicinity of the Fox Point hurricane barrier. On December 30, the Panamanian tanker, Grand Zenith, which was carrying a cargo of 8.2 million gallons of No. 6 fuel oil and a crew of 38, disappeared 50 miles off Cape Sable, Nova Scotia. On January 10, 1977, a smaller tanker, the Chester A. Poling, broke apart in a storm 8 miles off Gloucester, Mass. Although the vessel was not carrying a cargo of oil at the time, the incident caused the death of one of the crew members. Lastly, on January 28, 1977, the barge, Frederick E. Bouchard No. 65, ran aground on rocky shoals in an ice-covered section of Buzzards Bay, Mass., near Cleveland Ledge Light, and spilled approximately 100,000 gallons of No. 2 heating oil.

At this time, the long-term socioeconomic and/or environmental effects of the incidents are unknown. A few of the incidents, however, particularly the Argo Merchant and Buzzards Bay spills, will undoubtedly be fully investigated and well documented in the not too distant future.

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CAVEAT

Slight, insignificant errors occasionally exist among the data filed in the PIRS computer, and are attributable to improper coding when specifying parameters at the time the data were entered. Certain of these errors are carried over to the tables presented herein, since often it is impossible to trace their exact source. As a result, in Tables 3-6 minor inconsistencies are observed if one should compare column totals (representing total number or volume of spills for a given size category) in one table with corresponding column totals in remaining tables. Such errors do not affect the interpretation of the data. However, in order to document the total number and quantity of spills within each size category (Table 2), consistent values are necessary. Accordingly, the values appearing in Table 2 for a given size category were determined by averaging the sums of values appearing in corresponding columns from each of Tables 3-6.

TABLE 1. NUMBER AND QUANTITY OF OIL SPILLED PER ANNUM, 1973-1975

	Number spills	Quantity spilled (Gallons)
1973	560	> 490,862
1974	497	> 248,451
1975	467	> 282,789
TOTAL	1,524	> 1,022,102

TABLE 2. NUMBER AND QUANTITY OF SPILLS WITHIN EACH SIZE CATEGORY (1973, 1974, 1975)

Size category	Number	% Total	Quantity	% Total
0- 9 (Gal)	442	29.0	1,301	0.1
10- 49	381	25.0	7,273	0.7
50- 99	116	7.6	6,577	0.6
100- 499	162	10.6	32,070	3.1
500- 999	47	3.1	29,670	2.9
1K- 2.5K	36	2.4	53,049	5.2
2.5K- 5K	16	1.1	55,386	5.4
5K- 10K	16	1.1	107,276	10.5
10K- 50K	9	0.6	159,950	15.7
50K- 100K	3	0.2	200,000	19.6
100K-1000K	3	0.2	369,550	36.2
Over 1 Mil	None	-	None	-
Unknown Amt	293	19.2	?	-
TOTAL	1,524	-	> 1,022,102	-

TABLE 3. SIZE SPILL (GALLONS) VERSUS LOCATION (1973, 1974, 1975)

	0-9 Gal	10-49 Gal	50-99 Gal	100-999 Gal	500-999 Gal	1K-2.5K Gal	2.5K-5K Gal	5K-10K Gal	10K-50K Gal
Inland Waters									
No. of spills	114	78	20	30	7	4	3	5	1
Quantity	329	1,517	1,190	5,490	4,600	5,800	11,700	43,816	41,950
Coastal Waters									
No. of spills	307	288	91	128	39	29	13	11	7
Quantity	910	5,480	5,116	25,955	24,570	44,124	44,686	65,710	103,000
Open Waters									
No. of spills	1	3	1						1
Quantity	1	35	50						15,000
Contiguous Zone									
No. of spills									
Quantity									
High Seas									
No. of spills	19	11	5	3	1	2			
Quantity	65	210	250	400	500	2,500			

(continued)

TABLE 3. (continued)

	50K-100K Gal	100K-1000K Gal	Over 1 Mil Gal	Unknown Amt.	Row Totals	% Totals
Inland Waters						
No. of spills		1		21	284	18.7
Quantity		122,000			238,392	22.7
Coastal Waters						
No. of spills	3	2		246	1,165	76.5
Quantity	200,000	275,000			794,551	75.5
Open Waters						
No. of spills				2	8	.53
Quantity					15,086	1.4
Contiguous Zone						
No. of spills				1	1	0.07
Quantity					?	?
High Seas						
No. of spills				23	64	4.2
Quantity					3,925	0.37

TABLE 4. SIZE SPILL (GALLONS) VERSUS MATERIAL SPILLED (1973, 1974, 1975)

	0-9 Gal	10-49 Gal	50-99 Gal	100-499 Gal	500-999 Gal	1K-2.5K Gal	2.5K-5K Gal	5K-10K Gal	10K-50K Gal
Heavy Oil									
No. of spills	58	74	31	66	11	17	8	8	5
Quantity	195	1,405	1,795	14,695	7,300	24,024	29,186	56,250	100,950
Light Oil									
No. of spills	191	175	51	70	21	17	7	8	4
Quantity	563	3,469	2,954	12,835	12,840	26,000	24,700	53,276	59,000
Waste Oil									
No. of spills	59	63	11	11	4	1			
Quantity	190	1,269	577	1,910	2,830	2,300			
Other Oil									
No. of spills	135	68	24	16	11	2	1		
Quantity	352	1,114	1,285	2,755	6,700	2,100	2,500		

(continued)

TABLE 4. (continued)

	50-100K Gal	100-1000K Gal	Over 1 Mil Gal	Unknown Amt.	Row Totals	% Totals
Heavy Oil						
No. of spills	3	1		20	302	19.8
Quantity	200,000	105,000			540,800	57.3
Light Oil						
No. of spills		2		134	680	44.5
Quantity		182,200			377,837	40.0
Waste Oil						
No. of spills				22	171	11.2
Quantity					9,076	1.0
Other Oil						
No. of spills				117	374	24.5
Quantity					16,806	1.8

TABLE 5. SIZE SPILL (GALLONS) VERSUS SOURCE OF SPILL (1973, 1974, 1975)

	0-9 Gal	10-49 Gal	50-99 Gal	100-499 Gal	500-999 Gal	1K-2.5K Gal	2.5K-5K Gal	5K-10K Gal	10K-50K Gal
Dry Cargo Vessels									
No. of spills	1	1		3		1			
Quantity	1	10		426		2,300			
Tank Ships									
No. of spills	72	76	22	41	12	9	3	1	2
Quantity	198	1,487	1,278	8,312	8,130	10,624	10,486	5,250	25,000
Tank Barges									
No. of spills	13	11	5	11	5	1			
Quantity	44	245	295	1,820	3,640	2,000			
Combatants									
No. of spills	26	23	1	4	2	1	1		
Quantity	82	480	50	550	1,300	1,000	3,000		
Other Vessels									
No. of spills	64	61	14	12	1	4		1	
Quantity	192	1,131	702	2,575	500	4,600		5,860	
Land Vehicle									
No. of spills	11	8	7	8	2	3	2	3	
Quantity	42	170	400	1,624	1,000	5,100	8,200	22,600	
Non-Transportation Facility									
No. of spills	42	64	26	49	13	12	6	4	5
Quantity	132	1,232	1,455	10,403	8,100	19,079	22,200	27,000	78,000

(continued)

TABLE 5. (continued)

	0-9 Gal	10-49 Gal	50-99 Gal	100-499 Gal	500-999 Gal	1K-2.5K Gal	2.5K-5K Gal	5K-10K Gal	10K-50K Gal
Pipelines									
No. of spills	5	2		1	1	1			
Quantity	14	30		100	700	1,500			
Other Land Transportation Facility									
No. of spills	3	11	4	3	3	1	2	1	1
Quantity	9	265	215	525	1,700	2,221	7,000	5,000	15,000
Marine Facility									
No. of spills	26	25	9	5	1	2	1	3	1
Quantity	77	420	525	1,250	600	2,500	3,000	23,816	41,950
Miscellaneous Unknown									
No. of spills	180	100	28	25	7	1	1	3	
Quantity	509	1,827	1,616	4,460	4,000	1,500	2,500	20,000	

(continued)

TABLE 5. (continued)

	50-100K Gal	100-1000K Gal	Over 1 Mil Gal	Unknown Amt.	Row Totals	% Totals
Dry Cargo Vessels						
No. of spills				1	7	0.46
Quantity					2,737	0.26
Tank Ships						
No. of spills	2	1		24	265	17.4
Quantity	140,000	105,000			315,765	30.0
Tank Barges						
No. of spills				2	48	3.2
Quantity					8,044	0.76
Combatants						
No. of spills				4	62	4.1
Quantity					6,462	0.61
Other Vessels						
No. of spills				39	196	12.9
Quantity					15,560	1.5
Land Vehicles						
No. of spills	1			2	47	3.1
Quantity	60,000				99,136	9.4
Non-Transportation Facility						
No. of spills		2		28	251	16.5
Quantity		292,000			459,601	43.7

(continued)

TABLE 5. (continued)

	50-100K Gal	100-1000K Gal	Over 1 Mil Gal	Unknown Amt.	Row Totals	% Totals
Pipelines						
No. of spills					10	.70
Quantity					2,344	.26
Other Land Transportation Facility						
No. of spills				5	34	2.2
Quantity					31,935	3.0
Marine Facility						
No. of spills				5	78	5.1
Quantity					74,138	7.1
Miscellaneous						
Unknown						
No. of spills				182	527	34.6
Quantity					36,412	3.5

TABLE 6. SIZE SPILL (GALLONS) VERSUS CAUSE OF SPILL (1973, 1974, 1975)

	0-9 Gal	10-49 Gal	50-99 Gal	100-499 Gal	500-999 Gal	1K-2.5K Gal	2.5K-5K Gal	5K-10K Gal	10K-50K Gal
Casualty									
No. of spills	4	7	1	4	1	1			1
Quantity	13	105	50	600	900	1,500			15,000
Rupture and Other Structural Failures									
No. of spills	34	41	24	30	10	8	4	3	1
Quantity	105	933	1,345	6,270	5,700	12,500	13,200	21,600	15,000
Equipment Failure									
No. of spills	77	86	25	44	10	11	4	4	2
Quantity	228	1,623	1,409	8,003	6,900	17,400	13,986	28,250	24,000
Personnel Failure									
No. of spills	92	90	26	47	16	7	5	2	4
Quantity	272	1,812	1,535	10,283	10,370	10,824	18,200	14,816	95,950
Deliberate									
No. of spills	26	31	7	7	1	4	1	2	
Quantity	85	592	370	1,260	600	4,500	2,500	10,000	
Natural Disaster									
No. of spills	17	4	3	3					
Quantity	52	50	175	355					
Unknown									
No. of spills	192	123	30	28	9	5	1	4	1
Quantity	543	2,182	1,672	5,424	5,200	6,200	4,500	25,860	10,000

(continued)

TABLE 6. (continued)

	50-100K Gal	100-1000K Gal	Over 1 Mil Gal	Unknown Amt.	Row Totals	% Total
Casualty						
No. of spills	1	1		5	26	1.7
Quantity	85,000	105,000			208,168	20.0
Rupture and other Structural Failures						
No. of spills	1			11	167	11.0
Quantity	55,000				131,653	12.7
Equipment Failure						
No. of spills				21	284	18.6
Quantity					101,799	9.8
Personnel Failure						
No. of spills		1		15	305	20.0
Quantity		122,000			286,062	27.5
Deliberate						
No. of spills	1			19	99	6.5
Quantity	60,000				79,907	7.7
Natural Disaster						
No. of spills				11	38	2.5
Quantity					632	.06
Unknown						
No. of spills		1		211	605	39.7
Quantity		170,000			231,581	22.3

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16. ABSTRACT

The following report offers a comprehensive review of oil pollution incidents in and around New England waters. The first section of the report presents an analysis of all oil discharge data maintained by the U.S. Coast Guard for years 1973 through 1975. The data are analyzed categorically to reveal where most spills occur in New England waters, where the greatest quantities are spilled, what types of oil are most frequently spilled, what types are spilled in the greatest quantities (in gallons), what the most significant sources and causes of spills are, and within which size range (in gallons) most spills occur. The second section offers synopses of the more publicly recognized spills which have occurred within the last twenty-five years. The management of oil discharges and areas in which additional research is required are discussed in a concluding section.

Work for this report was completed as of February 14, 1977.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Water pollution	Data retrieval	New England oil spills	6F
Pollution	Oil recovery	Oil spill review	6T
Toxicity	Petroleum industry	PIRS	8A
Research management	Aquatic animals	Oil toxicity data	11H
Environmental surveys	Underwater environments	Resource management	
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Oils			

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